

1 TO WHOM IT MAY CONCERN:

2

3 BE IT KNOWN THAT I, DAVID W. WARREN, a  
4 citizen of the United States of America, residing in  
5 Glendale, in the County of Los Angeles, State of  
6 California, have invented a new and useful improvement  
7 in

8

9

10 COMPACT ENDOTHERMIC CATALYTIC

11 REACTION APPARATUS

12

13

14

15

16

17

18

19

20

21

22

23

24

25

1                   **BACKGROUND OF THE INVENTION**

2

3                   This application is a continuation-in-part of  
4   Serial No. 09/687,098 filed October 16, 2000.

5                   This invention relates to the use of  
6   endothermic catalytic reaction apparatus operable to  
7   produce hydrogen-containing gases from hydrocarbon  
8   feedstock.

9                   Endothermic catalytic reaction apparatus,  
10   for converting hydrocarbon feedstock to hydrogen-rich  
11   gases, is well known in the art. Commercial  
12   production of hydrogen is commonly achieved by a  
13   process known as steam reforming, that involves the  
14   endothermic reaction between a mixture of hydrocarbon  
15   feedstock and steam passed through a catalyst filled  
16   reactor tubing that is heated.

17                  In commercial steam reformers for large-  
18   scale production of hydrogen from hydrocarbon feeds,  
19   endothermic heat is commonly supplied by the  
20   combustion of carbonaceous fuel and oxidant in a  
21   diffusion or turbulent flame burner that radiates to  
22   the refractory walls of a combustion chamber, thereby  
23   heating them to incandescence, and providing a radiant

1 source for heat transfer to a tubular reaction  
2 chamber. Uniform radiation to the surfaces of the  
3 tubular reaction chamber is essential since excessive  
4 local overheating of the tube surface can result in  
5 mechanical failure. In large-scale commercial steam  
6 reformers, mal-distribution of heat within the furnace  
7 chamber is minimized by providing large spacing  
8 between the individual reactor tubes, the furnace  
9 walls, and the burner flames. However, for small-  
10 scale catalytic reaction apparatus that is uniquely  
11 compact, such as for the production of hydrogen for  
12 small fuel cell applications, special design features  
13 are needed to prevent tube overheating.

14 U.S. Patent 4,692,306 to Minet and Warren  
15 describes a compact reformer comprising an annular  
16 reaction chamber concentrically disposed around an  
17 internal burner chamber containing a vertically  
18 disposed cylindrical radiant burner that uniformly  
19 radiates in the radial direction. A uniform radiation  
20 pattern to a concentrically disposed annular reaction  
21 chamber that surrounds the radiant burner, is  
22 provided, thereby avoiding the problems with flame  
23 impingement and local overheating of tube surfaces